AD-756 335

PROCEDURE FOR HARDENING WELD METAL DURING ITS FORMATION

U. T. Sultanov, et al

Foreign Technology Division
Wright-Patterson Air Force Base, Ohio

9 February 1973

FTD-HT-23-1749-72

FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

PROCEDURE FOR HARDENING WELD METAL DURING ITS FORMATION

by

U. T. Sultanov, B. V. Umarov,
and M. A. Abralov

FOREIGN TECHNOLOGY DIVISION

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Fôreign Technology Division Air Force Systems Command U. S. Air Force	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

PROCEDURE FOR HARDENING WELD METAL DURING ITS FORMATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Translation

5. AUTHOR(S) (First name, middle initial, last name)

U. T. Sultanov; B. V. Umarov; M. A. Abralov

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
1970	12	2

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 60108 c. d. T72-01-40 T72-01-41	9a. ORIGINATOR'S REPORT NUMBER(S) FTD-HT-23-1749-72 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES Details of illustrations in this document may be better studied on microfiche.	12. SPONSORING MILITARY ACTIVITY Foreign Technology Division Wright-Patterson AFB, Ohio

13. ABSTRACT

A procedure ~~has been~~ developed for controlling the process of crystallization of metal in the molten pool. This procedure insures intensive influence, regulated within wide ranges, on the pool metal from the reverse side of weld, without direct contact with the latter. Structural analysis and mechanical tests showed that performing electromagnetic treatment during welding makes it possible to considerably refine the weld metal structure and to raise the physical properties of the obtained joints.

DD FORM 1 NOV 65 1473

I-a

UNCLASSIFIED

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Metal Crystallization						
Molten Metal						
Metal Welding						
Metal Refining						

FTD-HT- 23-1749-72

EDITED TRANSLATION

FTD-HT-23-1749-72

By: U. T. Sultanov, B. V. Umarov, and
M. A. Abralov

English pages: 7

Source: An UzSSR. Izvestiya. Seriya
Teknicheskikh Nauk. Gornoye Delo
Metallurgiya, No. 1, 1970, pp. 60-63.

Requester: FTD/PDTI

Translated by: SSgt Rene´ E. Courville

THIS TRANSLATION IS A RENDITION OF THE ORIGINAL FOREIGN TEXT WITHOUT ANY ANALYTICAL OR EDITORIAL COMMENT. STATEMENTS OR THEORIES ADVOCATED OR IMPLIED ARE THOSE OF THE SOURCE AND DO NOT NECESSARILY REFLECT THE POSITION OR OPINION OF THE FOREIGN TECHNOLOGY DIVISION.	PREPARED BY: TRANSLATION DIVISION FOREIGN TECHNOLOGY DIVISION WP-AFB, OHIO.

, I-C

U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

PROCEDURE FOR HARDENING WELD METAL DURING ITS FORMATION

U. T. Sultanov, B. V. Umarov, and
M. A. Abralov

With the use of welding in critical constructions, the mechanical indices of the weld metal are considered. A fine-grained structure with an insignificant chemical heterogeneity gives the metal high strength and plasticity.

Special technological methods during welding regulate the crystallization processes for obtaining the desired structures - for example, mixing liquid media (mechanical stirring, shaking at an ultrasonic frequency), adding modifier elements to the tail part of the pool through the filler material, measuring the cooling rate during the solidification of the molten pool, etc.

However, the difficulties in inducing oscillations into the limited volumes of the pool and the structural vibrations which appear in this case, as well as the complexity of the welding technology during the cooling phase delivery and the addition of modifiers, limit the possibilities of their use in practice.

In recent years, to raise the strength and plastic properties of construction materials it has been proposed that liquid media be mixed with the use of electromagnetic fields.

It has been established that a radical means for improving the structure and properties of the metal during electroslag welding is the electromagnetic mixing of the melt of the molten pool [1, 2], but there is no data on the effect of external magnetic fields on the crystallizations process of the metal in the pool.

In the proposed device electromagnetic fields, whose source is at the reverse side of the weld, act on the crystallization process of the molten pool. As a result of the interaction of the field with the welding current in the fusion zone, there arise electromagnetic forces which lead to the intensive mixing of the melt particles.

Specimens were welded and the obtained joints were treated electromagnetically in the apparatus (Fig. 1), consisting of a clamping device and a moving carriage with the source of the electromagnetic field made in the form of a coil with a steel core. The clearance between the electromagnetic field source and the surface of the specimens to be joined is regulated. The source of the controlling field is situated behind the weld; it therefore does not affect the stability of the arcing process and crystallization occurs without direct contact of the controlling equipment with the metal of the molten pool.

During welding the source of the electromagnetic field moves synchroniously with the movement of the pool. In the welder it is possible to carry on processing by the field when the axes of the electrode and the electromagnet coincide or are displaced at a certain distance. The electromagnet is supplied by current impulses of regulated duration, which alternate in terms

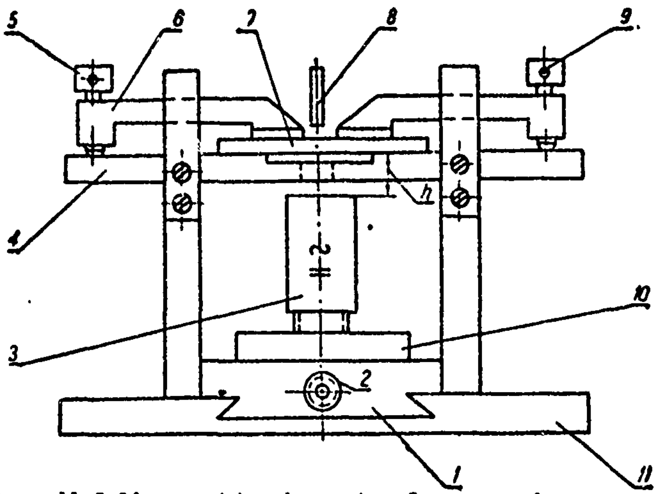

Fig. 1. Welding attachment; 1 - moving carriage; 2 - electric motor; 3 - electromagnetic coil; 4 - plate; 5, 6, and 9 - clamping device; 7 - weld specimen; 8 - electrode; 10 - lifting mechanism; 11 - base.

of polarity and which are separated by a regulated pause. Alternating and constant magnetic fields, whose intensity is controlled in a wide range, can act on the metal of the molten pool.

Field impulses alternating in polarity were obtained by supplying the field source from a special transformer. A rectifier unit on the low-voltage side of the transformer was used for the influence by the impulses of the constant field. The circuit diagram provides for inclusion into the primary winding of a power-supply transformer developed for the experiments, as well as a breaker which insures the flow of current impulses to the electromagnet with a duration from a half-period to 19 periods over a period. The pause duration was regulated from 0.02 s to 0.2 s by 0.02-second stages. The material was deformable, thermally unhardenable aluminum alloy AMg6. The investigation was conducted during automatic argon-arc welding on the ADSV-2 welder with a nonconsumable electrode without filler material. The welding conditions remained constant in the course of all the experiments and insured good weld formation from both sides.

For the specimens 3 mm thick, the welding parameters were the following: $I_{св}$ = 140-145 A; $U_д$ = 11-12 V; $v_{св}$ = 22-25 μ/h; Q_{Ar} = 16 l/min, $d_{эл}$ = 5 mm; the arc was supplied from an ac source, and brand A argon was used as shielding gas.

Specimens 100 × 200 mm in size were cleaned of surface oxide films by mechanical deburring, using a steel brush, and then were fastened by clips in an apparatus made of nonmagnetic materials (to eliminate the distortion of the controlling magnetic field).

The properties of the welded joints made by electromagnetic treatment during welding were studied by the macro- and microstructural analysis methods and by mechanical tests.

The dependence of the physical properties of AMg6 alloy on the parameters of the controlling field are given in the table. The results of the tensile tests confirm that for the majority of the control modes there is a corresponding increase in strength in comparison with the specimens welded without the effect. Structural studies of the metal of welds made under normal welding conditions and those treated by the examined procedure have established that the macrostructure of the metal in a weld made using the effect is more fine-grained (Fig. 2); the structure is refined in the axial part of the weld.

The active motion of the melt particles under the action of the controlling field leads to the crushing of the primary grain by the electromagnetic forces acting within the volume of the pool; the weld structure is refined and the intercrystalline interlayers of the columnar crystal zone become thinner. By changing the intensity of the controlling field and the nature of melt particle movement, it is possible to regulate the refined crystal zone in the metal of the weld.

Table

Mechanical properties	Tensile-test object							
	Without the field		Weld metal with effect					
	Parent metal	Weld metal	$B=18\cdot10^{-2}$ ml, $t_и=0{,}01$ s, $t_п=0{,}02$ s	$B=18\cdot10^{-2}$ ml, $t_и=0{,}02$ s, $t_п=0{,}04$ s	$B=18\cdot10^{-2}$ ml, $t_и=0{,}04$ s, $t_п=0{,}06$ s	$B=38{,}4\cdot10^{-2}$ ml, $t_и=0{,}04$ s, $t_п=0{,}08$ s	$B=38{,}4\cdot10^{-2}$ ml, $t_и=0{,}04$ s, $t_п=0{,}2$ s	$B=38{,}4\cdot10^{-2}$ ml, $t_и=0{,}06$ s, $t_п=0{,}1$ s
Tensile strength σ_B, kg/mm^2	$\frac{32}{31-33}$	$\frac{27}{26-28}$	$\frac{37}{36-38}$	$\frac{35}{34-37}$	$\frac{32}{31-33}$	$\frac{37}{36-38}$	$\frac{36}{34-37}$	$\frac{32}{31-33}$
Relative elongation δ, %	$\frac{16}{15{,}7-16{,}2}$	$\frac{13{,}6}{13{,}4-13{,}8}$	$\frac{18{,}2}{18{,}0-18{,}4}$	$\frac{17{,}4}{17{,}2-17{,}8}$	$\frac{16{,}2}{16{,}0-16{,}4}$	$\frac{18{,}4}{18{,}4-18{,}6}$	$\frac{18{,}1}{18{,}0-18{,}3}$	$\frac{16{,}3}{16{,}2-16{,}4}$

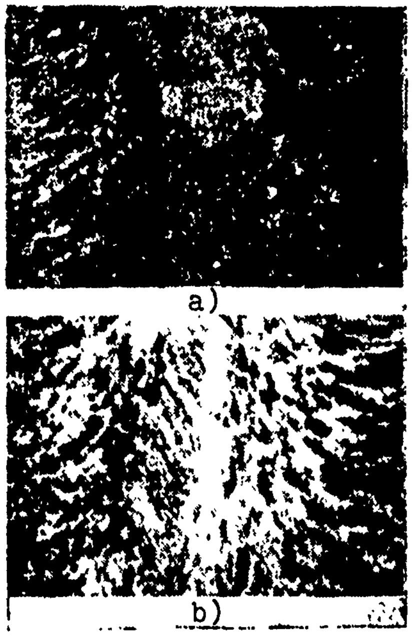

Fig. 2. Macrostructure of welds without a) and with b) the effect of an electromagnetic field.

The microstructure of the axial part of the weld made with electromagnetic treatment during welding differs sharply from the initial ones (Fig. 3).

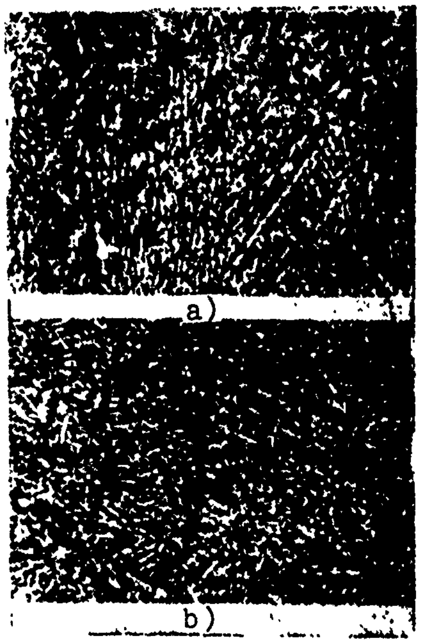

Fig. 3. Microstructure of the axial part of welds without a) and with b) the effect of an electromagnetic field.

CONCLUSIONS

1. A procedure has been developed for controlling the process of crystallization of matel in the molten pool. This procedure insures intensive influence, regulated within wide ranges, on the pool metal from the reverse side of the weld, without direct contact with the latter.

2. Structural analysis and mechanical tests showed that performing electromagnetic treatment during welding makes it possible to considerably refine the weld metal structure and to raise the physical properties of the obtained joints.

REFERENCES

1. Дудко Д. А. и Рублевский И. А. «Автоматическая сварка», 1960, № 9.
2. Трочун И. П., Черныш В. П. «Сварочное производство», 1965, № 11,

Tashkent Polytechnical
Institute

Received
22 August 1969